AD-A086 714 MASSACHUSETTS INST OF TECH LEXINGTON LINCOLN LAB F/G 20/14
A PREDICTOR MODEL FOR SHF AND EHF MILSATCOM SYSTEM AVAILABILITI--ETC(U)
FEB 80 L M SCHWAB F19628-80-C-0002
UNCLASSIFIED TN-1980-15 NL

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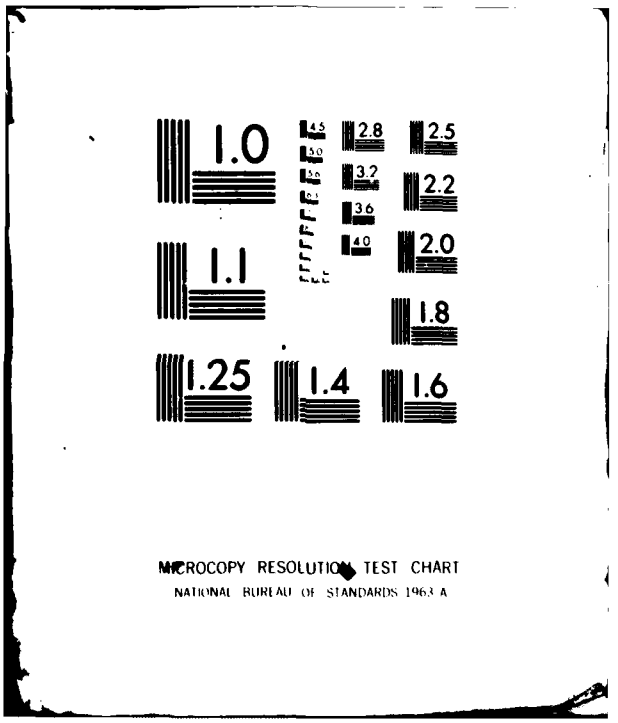
1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

```
 35
C**********************************************************************
C
C   PROGRAM NAME. SAPM IFTRAN
C   PURPOSE  GNERATE SYSTEM AVAILABILITY CONTOUR ON A MERCATOR WORLD MAP
C            WITH DRAWN SATELLITE VISIBILITY LIMIT
C   DATE 11/15/79
C   WRITTEN BY  YI-LEE CHEN LO
C
C
C
C   INPUT PARAMETERS:
C     IU.......DATA REFERENCE NUMBER
C     ITEK.....TEKTRONIC OUTPUT PARAMETER
C     FGHZ.....FREQUENCE IN GHZ
C     SATAV....SATELLITE AVAILABILITY
C     TERAVT...TERMINAL AVAILABILITY (TRANSMITTING)
C     TERAVR...TERMINAL AVAILABILITY (RECEIVING)
C     SATSUB...SATELLITE SUBPOINT
C     DBMRGN...MARGIN IN DB
C     RP.......TABULATED RAIN RATE FOR EACH OF THE 8 REGIONS
C
C
C
C   SUBROUTINES USED:
C   THIS PROGRAM IS RUN BY SAPM EXEC
C
C**********************************************************************
      IMPLICIT REAL*8(A-H.O-Z)
      REAL*4 SYSAV(72.29).LAT.LON
      DIMENSION NSP(8).RLAT(1000).RLON(1000).REG(8)
      DIMENSION RP(12.8).R(12).P(12).RINT(4).RAIN(4.4).B(4.1).WKAREA(28)
      DATA REG/'A'.'B'.'C'.'D'.'E'.'F'.'G'.'H'/
      DATA NSP/405.108.580.122.30.283.430.130/
      NAMELIST/SAPM/IU.ITEK.FGHZ.SATAV.TERAVT.TERAVR.SATSUB.DBMRGN.RP
C
C
C                             UTILIZE GRAPHIC ROUTINES IN GRLL
      NPLOTS=0
      CALL DATE(IMO.IDAY.IYR)
1     READ(5.SAPM.END=1000)
      IF(NPLOTS .EQ. 0)
      CALL TEKZZ(ITEK.0.'FF'.1)
      CALL TEKSCH('XS')
      CALL MODESG
      CALL SCOUTG(98.140.'S')
      CALL SETSMG(16.-1.0)
      CALL FILFRG(1)
      END IF
      NPLOTS=NPLOTS+1
C
C
C   COMPUTE ARFA(F). BETA(F). THE MULTIPLIER AND EXPONENT IN
C   ATTENUATION MODEL RESP.
C
      RPD=3.14159/180.
      F1=FGHZ/100.
      F2=F1**2
>
```

```
  95
        F3=F1**3
        F4=F1**4
        ARFA=1-EXP(-.11153*F1-2.983*F2-1.613*F3)
        BETA=0.94*(1+3.8406*F1-21.813*F2+48.8*F3-38.78*F4)
C
C
C   READ SAMPLE POINT LATITUDE AND LONGITUDE FOR EACH OF THE 8 REGION A-H
C
        IREG=30
        DO(NR=1,8)
C       WRITE(IU,333)REG(NR)
333     FORMAT(//2X,'REGION',3X,A1)
C       WRITE(IU,444)
444     FORMAT(/4X,'J',5X,'RLON',4X,'RLAT',6X,'SYSAU')
        IREG=IREG+1
        NJ=NSP(NR)
C       WRITE(IU,505)NJ
505     FORMAT(2X,'NJ=',I4)
        READ(IREG,111)(RLAT(J),J=1,NJ)
        READ(IREG,111)(RLON(J),J=1,NJ)
111     FORMAT(1X,5E(10F7.0))
C
        DO(KK=1,12)
        R(KK)=RP(KK,NR)
C       WRITE(IU,100)KK,R(KK)
100     FORMAT(2X,'KK=',I3,3X,'R(KK)=',F5.1)
        END DO
C
C   DETERMINE RAIN ATTENUATION FOR EACH (LAT,LON)
C
        DO(J=1,NJ)
        RABS=DABS(RLON(J)-SATSUB)
        IF(RABS .EQ. 0.0)
        ELEV=RPD*90.
        END IF
        IF(RABS .LE. 71.43 .AND. RABS .NE. 0.0)
        COSCOS=DCOS(RLAT(J)*RPD)*DCOS((RLON(J)-SATSUB)*RPD)
        XX=DSQRT(1+6.378**2-13.216*COSCOS)
        ANGSAT=DARCOS((6.378-COSCOS)/XX)
        ELEV=(RPD*90.-ANGSAT-DARSIN(XX*DSIN(ANGSAT)))/RPD
C       WRITE(IU,501)J,ELEV
501     FORMAT(2X,'J=',I3,3X,'ELEV=',F8.1)
        IF(ELEV .GE. 10.0)
        CCOSA=6.378/5.378*DCOS(ANGSAT)
        DIFF=CCOSA**2-7.378/5.378
        IF(DIFF .LT. 0.0)
        DIFF=0.0
        END IF
C       WRITE(IU,506)COSCOS,XX,CCOSA
506     FORMAT(2X,'COSCOS=',E18.11,3X,'XX=',E18.11,3X,'CCOSA=',E18.11)
        SLANT=20.*DLOG10(CCOSA-DSQRT(DIFF))
        ATTN=BETA*SLANT
C       WRITE(IU,556)SLANT,ATTN,ARFA,BETA
556     FORMAT(2X,'SLANT=',E18.6,4X,'ATTN=',F8.1,2X,3F8.3)
C
>
```

```
& 53
      COMPUTE MELTING LAYER HEIGHT. HT
C
      IF(NR.LE.4)
      C2=0.1549893113
      C4=-1.5475930877
      C6=-0.8719440530
      C8=1.4784124177
      ELSE
      C2=-0.27600
      C4=3.706036
      C6=-14.818189
      C8=12.032150
      END IF
C
      SINLAT=DSIN(RLAT(J)*RPD)
      HT=4.8*(1+C2*SINLAT**2+C4*SINLAT**4+C6*SINLAT**6+C8*SINLAT**8)
C
C
C     COMPUTE D.DELTA(D).GAMMA(D)
C
      IF(ELEV.EQ.90.0)
      GAMMA=1.0
      DELTA=0.0
      ELSE
      D=HT/DTAN(ELEV*RPD)
      IF(D.GT.22.5)
      D=22.5
      END IF
      BDL=D/4.5
      SDL=D/21.5
      GAMMA=1+BDL-0.230*BDL**2+0.0215*BDL**3
      DELTA=SDL-0.800*SDL**2+0.446*SDL**3
      END IF
C
C
C     COMPUTE RAIN RATE. RR. FOR EACH POINT
C
C     WRITE(IU.200)J.HT.DELTA.GAMMA
200   FORMAT(2X.'J='.I3.'HT='.F6.1.3X.'DELTA='.F6.3.3X.'GAMMA='.F6.3)
      RR=DEXP(DLOG(ATTN*DSIN(ELEV*RPD)/(HT*ARFA*GAMMA))/(BETA-DELTA))
C
C     FIND % OF YEAR EXCEEDANCE. PROB.VIA CARVE FITTING
C
      CALL POFRR(R.RR.PROB.IU)
      END IF
      END IF
C
C     FIND SAMPLE POINT INDICES (NLAT.NLON) FROM (RLAT.RLON)
C
      LAT=RLAT(J)
      LON=RLON(J)
      NLAT=19+IFIX(LAT/5.)
      NLON=37+IFIX(LON/5.)
C     WRITE(IU.300)NLAT.NLON
300   FORMAT(2X.'NLAT='.I4.4X.'NLON='.I4)
>
```

```
$ SS
C   FOR POINTS WITHIN THE SATELLITE VISIBILITY LIMIT,
C   GENERATE SYSTEM AVAILABILITY, SYSAV, FROM TERMINAL AVAILABILITY,
C   TERMAV & TERMUN, SATELLITE AVAILABILITY SATAV,AND % OF YEAR
C   EXCEEDANCE, PROB
C
      IF(RABS .LE. 71.43 .AND. ELEV .GE. 10.)
      SYSAV(NLON,NLAT)=(1.-PROB)*SIZE*TERRAV*TERRAV*SATAV
C     WRITE(IU,221)J,SYSAV(NLON,NLAT)
221   FORMAT(2X,'J=',I4,3X,'SYSAV=',F8.4)
C     WRITE(IU,222)J,NLON(J),NLAT(J),SYSAV(NLON,NLAT)
C     WRITE(IU,222)J,NLON,NLAT,SYSAV(NLON,NLAT)
222   FORMAT(2X,I3,3X,I4,3X,I4,4X,F8.4)
      ELSE
      SYSAV(NLAT,NLON)=0.0
      END IF
      END DO
      END DO
      CALL FILPRB(1)
      GO TO 1
1000  REWIND 5
      CALL EXIT
      RETURN
      END
EOF
>
```

APPENDIX C

HPL LISTING OF MAIN PROGRAM
(HP-9825)

```
0: dim C[8,12],R[8,9,4],N[520],O[2,725]⁞sfg 14⁞ldf 9,R[*]
1: .0001→C[1,1]⁞.0001→C[2,1]⁞.0001→C[3,1]⁞.0001→C[4,1]⁞.0001→C[5,1]
2: .0001→C[6,1]⁞.0001→C[7,1]⁞.0001→C[8,1]
3: 1.1→C[1,2]⁞1.2→C[2,2]⁞1.2→C[3,2]⁞1.8→C[4,2]⁞2→C[5,2]⁞.4→C[6,2]
4: 1.7→C[1,3]⁞1.8→C[2,3]⁞1.9→C[3,3]⁞3→C[4,3]⁞4→C[5,3]⁞.8→C[6,3]
5: 2.5→C[1,4]⁞2.7→C[2,4]⁞2.8→C[3,4]⁞5.2→C[4,4]⁞8.5→C[5,4]⁞1.2→C[6,4]
6: 4→C[1,5]⁞4.8→C[2,5]⁞4.8→C[3,5]⁞9.5→C[4,5]⁞21→C[5,5]⁞3.2→C[6,5]
7: 6.5→C[1,6]⁞6.8→C[2,6]⁞7.2→C[3,6]⁞15→C[4,6]⁞35→C[5,6]⁞5.5→C[6,6]
8: 8→C[1,7]⁞9.5→C[2,7]⁞11→C[3,7]⁞22→C[4,7]⁞52→C[5,7]⁞8→C[6,7]
9: 12→C[1,8]⁞14→C[2,8]⁞18→C[3,8]⁞35→C[4,8]⁞77→C[5,8]⁞14→C[6,8]
10: 15→C[1,9]⁞19→C[2,9]⁞28→C[3,9]⁞49→C[4,9]⁞98→C[5,9]⁞23→C[6,9]
11: 19→C[1,10]⁞26→C[2,10]⁞41→C[3,10]⁞64→C[4,10]⁞117→C[5,10]⁞34→C[6,10]
12: 24→C[1,11]⁞40→C[2,11]⁞62→C[3,11]⁞86→C[4,11]⁞144→C[5,11]⁞51→C[6,11]
13: 28→C[1,12]⁞54→C[2,12]⁞80→C[3,12]⁞102→C[4,12]⁞164→C[5,12]⁞66→C[6,12]
14: 1.6→C[7,2]⁞2.8→C[8,2]⁞3.7→C[7,3]⁞6.4→C[8,3]
15: 7→C[7,4]⁞13→C[8,4]⁞14→C[7,5]⁞31→C[8,5]⁞22→C[7,6]⁞51→C[8,6]
16: 33→C[7,7]⁞77→C[8,7]⁞51→C[7,8]⁞115→C[8,8]⁞67→C[7,9]⁞147→C[8,9]
17: 85→C[7,10]⁞178→C[8,10]⁞109→C[7,11]⁞220→C[8,11]⁞129→C[7,12]⁞251→C[8,12]
18: ent "LINK MARGIN PARAMETER in dB=?",M
19: ent "FREQUENCY in GHz(<50)=?",r0
20: ent "SUBPOINT in degr.(+=E,-=W)=?",S
21: ent "SATELLITE AVAIL.(0.xxx)=?",r2
22: ent "TERMINAL AVAIL.(0.xxx)=?",r3
23: 0→r27
24: 1→r28
25: r0/100→r0
26: 1-exp(.1115r0-2.02r0r0-1.01r0↑3)→r4
27: .9(1+3.8408r0-21.81r0↑2+48.8r0↑3-39.7r0↑4)→r5
28: r27+1→r27
29: if r27>8⁞gto "end"
30: ldf r27,N[*]
31: for I=1 to 520
32: if N[I]=0⁞gto "next"
33: 70-5int((N[I]-1)/72)→r6
34: ((N[I]-1)mod72)5→r7
35: if r7>180⁞r7-360→r7
36: r((r7-S)(r7-S))→r30
37: if r30>180⁞360-r30→r30
38: if r30>71.43⁞gto "next point"
39: r(44.665664-13.216cos(r6)cos(r7-S))→r8
40: acs((6.608-cos(r6)cos(r7-S))/r8)→r9
```

```
41: 1.178317cos(r9)→r10
42: 20log(r10-r(r10r10-1.356633))→r11
43: 90-r9-asn(r0sin(r9))→r12
44: if r12<10:goto "next point"
45: if r0>.22:jmp 3
46: exp(-.617564r0+43.2368r0↑2-444.45r0↑3+1358r0↑4)-1→r29
47: jmp 2
48: exp(13.03032r0-81.6987r0↑2+156.48r0↑3-74r0↑4)-1→r29
49: r29/sin(r12)→r29
50: sin(r6)↑2→r13
51: if r27>4:goto +3
52: 4.8(1+.154989r13-1.547593*r13↑2-.871944*r13↑3+1.472412*r13↑4)→r14
53: goto +2
54: 4.8(1-.276r13+3.705036r13r13-14.212189r13↑3+12.032159r13↑4)→r14
55: r14/tan(r12)→r15
56: r15/4.5→r16
57: r15/21.5→r17
58: 1+r16-.23r16r16+.0215r16↑3→r18
59: r17-.98r17r17+.446r17↑3→r19
60: M-r11-r29→r20
61: exp(ln(r20sin(r12)/(r14*r4*r18))/(r5-r19))→r21
62: 3→r22
63: if r21<C[r27,r22]:goto 67
64: r22+1→r22
65: if r22>12:.00001→r26:goto 71
66: goto 63
67: r22-2→r22
68: if r22>9:9→r22
69: R[r27,r22,1]+R[r27,r22,2]r21+R[r27,r22,3]*r21↑2+R[r27,r22,4]*r21↑3→r23
70: exp(r23)→r26
71: 1-r26→r24
72: r2*r3*r24→r25
73: N[I]→O[1,r28]
74: r25→O[2,r28]
75: 1+r28→r28
76: "next point":next I
77: "next":goto 28
78: goto "next point"
79: "end":rcf 10,O[*]
80: end:stp
*15505
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A numerical method for computing MILSATCOM system availability based on predicted link availability is described. Link availability can be computed in the model for frequencies of 10-50 GHz, arbitrary geostationary satellite subpoint, and arbitrary value of link margin in dB. Computed availability contours are plotted on a Mercator grid of the world.

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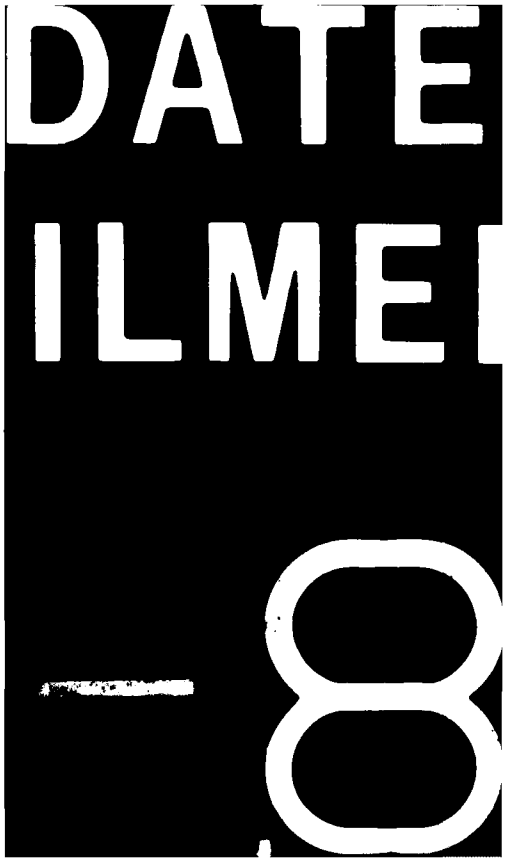
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